International Council for the Exploration of the Sea

C.M. 1982/F:1
Administrative Report

MARICULTURE COMMITTEE

by

Dag Møller

1981

BELGIUM

(G.Persoone)

The pilot-scale installation for nursery culturing of bivalve molluscs, built at the Belgian coast in 1979 has been in operation throughout 1981 ; a number of technological adaptations have been made to improve the efficiency of the systems.
An international workshop on nursery culturing of bivalve molluscs has been organized at the Laboratory for Mariculture at the State University of Ghent, the proceedings of which have been printed by the European Mariculture Society as Special Publication No. 7 (2 reviews, 16 experience papers + the full transcripts of 3 round tables).

The European Mariculture Society (the registered Office of which is located at the Institute for Marine Scientific Research in Belgium) has organized, jointly with the World Mariculture Society, a World Conference on Aquaculture and an International Aquaculture Trade Show, in Venice, Italy. During this Conference, which was attended by approximately 1100 persons from 56 countries, the topics "Realism in aquaculture - Achievements - Constraints - Perspectives" were treated in 25 review papers, 160 poster papers, three panel sessions and five special meetings.

The culture unit for batch production of Artemia at the Belgian coast is operated in routine fashion ; various technical improvements have resulted in over 90 % reliability of production yields of minimum 5 kg live weight biomass per m^3 and per 2 weeks batch farming.
A pilot scale system for flow-through production of Artemia using the effluent of a geothermal brine well, has been set up and operated in Turnhout (150 km inland). Using a new culture technology production yields of up to 25 kg per m^3 can be attained.
Research at the Artemia Reference Center is furthermore focusing on comparative studies with different Artemia strains aiming to improve their use in aquaculture hatcheries and to select appropriate strains for intensive culturing and innoculation purposes. The latter studies are integrated within the framework of the International Study on Artemia, an international inter-disciplinary study on Artemia strains coordinated by the ARC.
From May 4 through May 22nd the "2nd International Training Course on the Biology and Practical Use of the Brine Shrimp Artemia in Aquaculture" has been organized at the State Univerity of Ghent. It was attended by 20 trainees from 11 countries.

CANADA

(J.E.Stewart)

Pacific Coast

Shellfish:

An investigation into the feasibility of culture of the Weathervane Scallop Patinopecten caurinus has been initiated. Presently based on field collection of natural spat, the intent is to develop hatchery seed production methods.

One commercial oyster hatchery continued to operate. In 1982 this will offer eyed larvae for sale to growers to set for subsequent culture.

A private hatchery for abalone (Haliotis sp.) has successfully reared juveniles. The intent is to provide seed for enhancement of natural stocks. The economics of production are presently limiting.

Culture of the Manila clam (Tapes philippinarum) is being carried out to develop technology and investigate commercial feasibility.

Finfish

Nutrition:

In comparative tests, locally developed open-formula West Van diets show a 20% advantage over other test diets in cost/lb of fish meat production.

Selective Breeding:

Comparative growth studies are continuing using imported stocks (Norway and Isle of Man), a native stock (Spring Valley) and their crosses. A cross between Norwegian and Spring Valley stocks shows best overall performance after three generations. In marine cage culture rainbow trout show superior growth and flesh yield to any of the Pacific salmon species.

Herring (Clupea harengus):

Much of the federal effort formerly diverted to experimental salmonid cage culture has been diverted to developing technology for cage holding of herring for roe production.

In 1981 a lot of 7 tons held for three months showed excellent survival (97%) and yielded high quality roe. Gonad development was found to be largely

independent of holding conditions, feeding etc. A holding density of 8 kg/m^3 appears to be limiting, above this level fish develop a general bacteraemia.

In 1982 two large cage lots of 20 tons each, plus 10 tons in smaller experimental lots, are being held to further investigate and develop applicable technology and assess the economic viability and applicability of the concept.

Atlantic Coast

Mussel:

Commercial culture of the Blue Mussel (Mytilus edulis) continues to show rapid growth especially in Prince Edward Island and Nova Scotia. Six operations marketed mussels in 1981 but twenty-five operations have stock growing and project production of over 200 metric tons in 1982 and twice this in 1983. In Newfoundland a major new operation began in 1981. All existing operations are still developing and will market in 1983.

Scallops:

In Prince Edward Island the introduced Bay Scallop (Aequipecten irradians), after four generations reared in total quarantine, has been approved for holding in controlled flow-through conditions for further observation and evaluation.

Experimental rearing of naturally produced seed of the Icelandic Scallop (Chlamys islandica), in Newfoundland has shown lower growth rates than the Sea Scallop (Placopecten magellanicus).

Commercial and experimental rearing of Placopecten magellanicus continued at four sites in Newfoundland. The Marystown operation supplied 10,000 2 year olds to the French island of St. Pierre and has contracted to provide four to five times this number in 1982. The project rearing stock for natural enhancement in Port au Port Bay experienced a near total spat failure in late 1980. The 1981 set appears to be good.

In attempts to hatchery rear this species, larvae have been successfully raised to pediveliger stages consistently, with advances in feeding techniques, but show high mortalities subsequently. Nutritional deficiences are suspected as a major contributing factor.

Lobster:

Juvenile lobsters (initial weight 30 mg.) grew and survived well on ascorbic acid-free purified test diets for four months and reached a mean weight of 800 mg. Both in vivo and in vitro studies with C^{14} - glucose, demonstrated de novo synthesis of ascorbic acid by large juveniles (300-400 gm.). The rate of such synthesis was greatest at the pre-smolt stage and least at intermolt.

Lobsters have a dietary requirement for copper which they appear to be able to satisfy by absorption from seawater. Low dietary levels of copper reduce growth slightly. Higher levels reduce growth and result in increased deposition of silver in the hepatopancreas proportional to dietary copper. Diets containing intermediate copper levels and silver salts resulted in improved growth and survival.

Purified protein from the rock crab (Cancer irroratus), has proven to be a significantly superior protein source in lobster test diets. Similar studies are underway with several other crustacea including Macrobrachium rosenbergii, several penaeid shrimp and crab species. It is hoped that this purified crab protein will be produced in sufficient qualities to allow it to replace casein and egg albumin as the standard reference protein in lobster and other crustacean nutrition research.

Finfish

Atlantic Salmon:

Commercial culture of this species continues to expand, the major constraint being the supply of smolts. Nine private operations in various stages of development are rearing salmon in marine cages, and one in tanks fed by pumped seawater. Six of these are on the Bay of Fundy coast of Southwestern New Brunswick, the major area of established potential. In Newfoundland studies on site selection and hatchery development are continuing in the Bay d'Espoir area.

Sea ranching trials continued in 1981 with the release of 24,000 smolts at Dark Harbour, Grand Manan, N.B. This location was chosen because of the lower number of herring weirs in the immediate area and the prospect of fewer smolts and returning adults being taken incidentally in the herring fishery. A delayed release (June 29) following 2 months' retention in sea cages was used to maximize returns.

Long-term laboratory and field studies are continuing to study possible environmental control of sexual maturation in cage-reared Atlantic salmon. The pattern of maturation in a given salmon stock, reared in sea cages, continues to differ from those as a result of sea ranching. Low winter-water temperatures in sea cages compared to ocean-feeding grounds are believed to be involved in producing this result. Lab studies to elucidate the role of winter-water temperatures, in particular the role of temperature-mediated nutritional state on the timing of sexual maturation, are being conducted.

Rainbow Trout:

The major trout grower, in the Bras d'Or Lakes of Nova Scotia, is now virtually self-sufficient in egg supplies, providing a potential for development of selected local stocks for marine cage rearing. Another private operation in Nova Scotia is engaged in the early stages of stock selection with both Atlantic salmon and rainbow trout. In Newfoundland stocks introduced from Ontario show growth rates twice those of native stocks, in marine cages.

The rainbow trout, an exotic to the region, represents a potential threat to Atlantic salmon by the establishment of competing wild populations through escapes from culture operations. Area restrictions on the culture of this species exist in the Maritime Provinces and have now been instituted in Newfoundland.

Eels:

An experimental grow-on facility, designed to rear undersized eels from the commercial fishery to market size is operating in early developmental stages in Bay d'Espoir, Newfoundland.

Disease and Nutrition

Vaccines:

A laboratory study was conducted in 1981 to test the efficacy of an experimental vaccine in the prevention of vibriosis in pink salmon. The results were encouraging and further trials in the laboratory as well as field trials are planned for 1982.

Vaccines against vibriosis, produced in the private sector under a continuing federal contract will be field tested at a number of sites in 1982 as a part of further development and for licensing purposes.

Furunculosis in Cod

Investigation of a mild epizootic in Atlantic cod, Gadus morhua, held in experimental tanks revealed infection by an aberrant strain of Aeromonas salmonicida, the organism responsible for furunculosis in salmonids. Infection of both cod and Atlantic salmon, Salmo salar, using cultured isolates, resulted in development of symptoms and death, suggesting that wild cod may represent a potential reservoir of infection of this organism for salmonids in marine cages.

Bacterial Kidney Disease

Studies on bacterial kidney disease of Atlantic salmon to determine the role of nutrition as a possible prophylactic method to minimize Bacterial Kidney Disease (BKD) infections and occurrence and severity yielded significant findings. Results indicate that fish fed a diet containing high levels of iodine and fluorine (4.5 mg/kg of diet) had a low incidence (3.6%) of BKD as compared to those maintained on commercial feed (36%). The above levels of iodine and fluorine in the presence of high levels of zinc and magnesium did not provide the same protection. It appears that some minerals may affect the availability of I and F from the diet and their metabolism. The level of I and F in the diet seems to be more critical during Parr-Smolt transformation.

ANNUAL MARICULTURE PRODUCTION - CANADA

(1981 Production Unless Otherwise Noted)

PACIFIC COAST	METRIC TONS	NUMBER	$U.S. (000's)
Oyster (*Crassostrea gigas*)			
Shucking (in shell)	2,400	)	1,010
Singles		480,000)	
Mussel (*Mytilus edulis*)	10		10
Salmon (*Oncorhynchus sp.*) (1980)	72		N/A
Rainbow Trout (*Salmo gairdneri*)			
Food market	28		N/A
Stocking	10		N/A
Fish-out	8		N/A
ATLANTIC COAST			
Oyster (*Crassostrea virginica*)			
In shell	700		1,279
Mussel (*Mytilus edulis*)	82		69
Salmon (*Salmo salar*)	28		235
Rainbow Trout (*Salmo gairdneri*)	86		300

Denmark

No report received.

Finland

(P. Tuunainen)

Mariculture in Finland is based on one hand on sea ranching of salmon (Salmo salar), sea-trout (Salmo trutta trutta) and migratory whitefish (Coregonus lavaretus) by introducing smolts of salmonids and 1-summer old whitefish young into the sea. On the other hand it is based on production of rainbow trout (Salmo gairdneri) in net cages and enclosures for human consumption. Mariculture production is continually increasing. This is caused by good domestic markets for rainbow trout and by efforts to increase the volume of sea ranching of the species mentioned above. As a new species for marine net cage culture the Baltic salmon (Salmo salar) is gaining more and more interest and small-scale experiments in this field have been started.

Except fish farming restoration of salmon and sea-trout rivers is going on and remarkable increases in the numbers of parrs in the restored rapids have been reported. In one of the rivers, Simojoki, flowing into the Bothnian Bay constant monitoring program is going on.

Study programs were also carried out to find out the production biological and economic results of the introductions for sea ranching, to improve the quality of reared fish young, to measure the quality by physiological tests and by tagging the fish. Work has also been done to improve the fish feeds, rearing methods and to decrease water pollution caused by larger fish farms.

OUTLINE FOR STATISTICAL INFORMATION ON MARICULTURE PRODUCTION +)

Mariculture production 1980 (figures for 1981 not yet available)

Country: Finland

Species	in metric tons	approx.number in 100 000	value in 1 000 US $
Rainbow trout in enclosures more than 0.5 kg each	1 958	-	8 900
Salmon for introductions, 2 years and older	-	5,07	900
Other salmonids (specify): Sea-trout for introductions 2-summer old and older		7,58	970
Others (please specify): Migratory whitefish for introductions 1-summer old		88,76	650

+) Clear working definitions should be provided for terms used i.e. seed vertical culture, seed laboratory reared etc.

FRANCE
(J.Audouin)

- Mollusques, Crustacés et Algues

Mollusques :

Pectinidés :

Pecten maximus

Les essais de captage de naissain de coquilles Saint Jacques, réalisés en Baie de Saint Brieuc (Comité d'Expansion économique et CNEXO) n'ont pas donné de bons résultats depuis trois ans.

Le recours à l'importation a été envisagé et des recherches ont été menées en écloserie pour la production de naissain (SATMAR - COB). Malgré des difficultés, une certaine quantité de naissain a pu être fournie. Le prélevage ne semble pas poser de problèmes majeurs : des essais ont été réalisés en Rade de Brest par le COB et le Comité local des Pêches Maritimes et en Baie de Saint Brieuc par le Comité d'Expansion économique.

Chlamys varia

En Baie de Quiberon, le suivi de la reproduction du pétoncle noir Chlamys varia et l'immersion de collecteurs expérimentaux ont été poursuivis en 1981 (ISTPM) en vue d'améliorer les connaissances sur la température minimale nécessaire pour la survie des larves et la durée de la phase larvaire.

Les essais de captage et le suivi des juvéniles, réalisés en Rade de Brest COB - Comité local des Pêches Maritimes) ont donné des résultats très encourageants.

Vénéridés :

Les expériences d'élevage se sont poursuivies dans de nombreux sites de la côte Atlantique. Ils portent essentiellement sur Ruditapes philippinarum.

Dans le secteur de La Trinité S/Mer, un essai de transfert des résultats acquis à la profession, a été réalisé : un parc de 400 m^2 a été ensemencé à raison de 300 palourdes au m^2 et protégé par un barrage et des filets. Un essai a été réalisé sur des individus de petite taille : il a échoué à cause de la prédation.

Trois expériences de prégrossissement ont été faites à la demande des professionnels.

En Baie de Bourgneuf, l'essentiel des travaux a porté sur le prégrossissement en claire et la mise en route d'une nourricerie expérimentale.

Dans la région de La Rochelle, différents essais d'élevage (ISTPM) ont été réalisés en milieu ouvert afin de mettre en valeur des vasières inexploitées. Des dispositifs de protection ont été adaptés au site.

Dans le secteur de La Tremblade, l'assistance technique a été apportée par l'IPTPM à de nombreuses nurseries et des expériences comparatives ont été faites.

Dans le cadre du "programme national palourdes" (CNEXO - ANVAR) 1 500 000 palourdes ont été semées. De graves problèmes consécutifs à la prédation ont été rencontrés. Il en a été de même à Arcachon. Dans le secteur de Bouin, des élevages ont été mis en place avec suivi ISTPM dans le cadre du programme précité.

Ostréidés :

Huître plate

Ostrea edulis

La régression de la maladie due à Marteilia refringens semble s'être confirmée en 1981. Les secteurs qui restent touchés sont en Bretagne sud : rivière de Pénerf pointe de Penvins, rivière d'Auray et Golfe du Morbihan et en Bretagne nord les gisements naturels de la rade de Brest à l'exception de Roscanvel.

Tous les centres importants d'élevage sont touchés par l'épizootie due à Bonamia ostreae à l'exception de la partie sud-est de la rade de Brest (secteur de Loumergat) et des côtes méditerranéennes. Les mortalités constatées sont comprises entre 50 et 90 %. Contrairement aux huîtres de 18 mois, 2 ans et 3 ans, le naissain est peu affecté (0,12 %) par la maladie.

Les essais d'infestation expérimentale en laboratoire ont montré que la contamination peut se faire directement d'huître à huître par l'intermédiaire du milieu.

La production de naissain est évaluée à 200 tonnes environ. La production d'huîtres à la consommation n'aurait pas dépassé 2 000 tonnes.

Huître creuse

Crassostrea gigas

Les facteurs limitant susceptibles de perturber le déroulement du cycle sexuel et le comportement des larves d'huîtres ont été étudiés (ISTPM La Tremblade) ainsi que la croissance en relation avec les facteurs de l'environnement.

Les études sur les anomalies de la calcification sur le chambrage avec production de gel se sont poursuivies, en relation avec l'action des peintures anti-foulir

Mytilidés :

Moule

Mytilus edulis

Des essais de techniques nouvelles de culture de la moule ont été entrepris dans la baie de l'Aiguillon et dans le secteur du Guilvinec en vue d'augmenter la production.

Algues :

Les études concernant la possibilité de culture de l'algue Euchema spinosum aux Antilles ont été poursuivies en 1981 (ISTPM), à l'Ile Saint Martin, en Guadeloupe et en Martinique.

Dans une première étape, de petites unités de culture ont été mises en place en divers points pour localiser les zones où la croissance s'avérait être la meilleure. Dans un deuxième temps, des unités plus grandes ont été construites afin de s'approcher des conditions de la culture intensive. Plusieurs méthodes d'ensemencement ont été appliquées et divers types de techniques ont été utilisées.

Crustacés :

Homard

La production de post-larves des écloseries a été la suivante en 1981 :

Ecloserie de l'Ile d'Yeu (ISTPM-ARFAC) : 156 000 post-larves et 10 000 juvéniles

Ecloserie de l'Ile d'Houat (APASUB) : 107 000 post-larves et 10 000 juvéniles

Ecloserie de l'Ile de Sein : 20 000 post-larves

L'étude comparative de la croissance en captivité du homard européen, du homard américain et des hybrides s'est poursuivie (ISTPM). Une étude comparative de ceux-ci par électrophorèse des protéines sériques a été entreprise (ISTPM).

Des études portant sur le comportement du homard et sur les moyens de marquages ont été menées au vivier du Pérello (APASUB).

SALMONIDES (J. Guillaume)

Des recherches ont été poursuivies sur le *Oncorhychus kisutch*, *Salmo salar*, *Salmo gairdneri* et *Salmo trutta*.

Sur le saumon coho des essais à caractère empirique ont été conduits en vue d'obtenir la reproduction de cette espèce maintenue en eau douce. Des résultats encourageants ont été obtenus. D'autres expériences ont été réalisées dans le domaine de la nutrition (premières études des besoins en eau de mer et aliments facilitant le transfert) et de l'élevage en mer : le saumon coho s'est avéré capable de supporter les conditions estivales dans certains sites de la côte atlantique après un transfert printanier.

Les expériences sur le saumon atlantique ont surtout concerné les techniques d'élevage dans les conditions climatiques de l'Ouest de la France. Grâce à des progrès constants un pourcentage élevé de smolts d'âge 1 peut maintenant être obtenu.

La truite fario, issue d'une population synthétique française, s'est avérée à nouveau être un poisson apte à l'élevage en mer supportant bien le transfert direct en eau salée et les conditions estivales. La truite fario migratrice polonaise donne des résultats nettement moins intéressants.

Des essais de transfert en mer avec dosage préalable de l'activité ATP asique ont été effectués de façon comparative sur les quatre espèces étudiées.

POISSONS MARINS

Les recherches ont surtout été poursuivies sur *Solea solea* et *Psetta maxima*.

L'intérêt d'un enrichissement des proies vivantes (rotifères) à l'aide de nutriments (acides gras et vitamines) et d'antibiotiques a été confirmé. Cette technique permet d'obtenir une diminution spectaculaire de la mortalité des larves de turbot et d'améliorer leur croissance après le sevrage.

De nouveaux élevages expérimentaux de soles ont été conduits avec sevrage pendant la phase pélagique. La survie est aussi élevée qu'avec un sevrage tardif mais la croissance est ralentie.

Après le sevrage diverses expériences ont été réalisées à l'aide d'aliments extrudés : ces aliments une fois réhydratés, éventuellement imbibés d'attractants, s'avèrent beaucoup plus appétents que les aliments secs, surtout chez la sole. Chez le turbot ils s'avèrent cependant moins efficaces que les aliments en pâte humide.

Les essais de production intensive de soles âgées de 18 mois à l'échelle expérimentale se sont avérés décevants : seul un pourcentage réduit de la population atteint une taille marchande à cet âge.

Signalons que les juvéniles de turbot ont été atteints d'une mortalité massive due à *Vibrio anguilarum*.

MOLLUSQUES

La production de jeunes ormeaux *Haliotis tuberculata* a été poursuivie dans l'écloserie expérimentale du CNEXO. Les essais d'élevage en habitats artificiels de divers types se poursuivent également tandis que le premier cycle complet d'élevage s'est achevé sur le bilan suivant : recapture 33 % , poids moyen à l'âge de 4 ans : 45 g.

Un programme sur la reproduction artificielle de la coquille St Jacques *Pecten maximus* a été mis en place. De notables progrès ont été accomptés sur les phases larvaires et de métamorphose : tandis que des essais d'élevage extensif des juvéniles sont entrepris après semis sur le fond.

Sur la palourde *Ruditapes philippinatum* les essais se poursuivent au niveau du développement. Le rôle de la taille du naissain des techniques d'élevage et des sites fait l'objet d'études comparatives.

CRUSTACES

Les recherches conduites sur *Penaeus japonicus* ont surtout concerné le déterminisme de la maturation sexuelle et l'effet de l'âge des reproducteurs. La photophase semble être l'agent essentiel déclanchant la maturation ovarienne.

Dans le domaine de la nutrition, les expériences ont surtout concerné les besoins en acides aminés et en minéraux, ainsi que le rôle du mode de distribution de la nourriture qui influence le lessivage et, partant la croissance.

./.

GERMAN DEMOCRATIC REPUBLIK

(W. Loos)

According to research and development programms in the field of mariculture the following activities were carried out in 1981.

1. Experiments on rearing fry of rainbow trout im heated brackish water were continued. Biotechnical factors and technological and technical equipment were studied in various tests. The results will be applied to the draft of the pilot project for utilization of heated brackish water .
   Furthermore the results underline again the need to continue work on a rainbow trout stock resistent against diseases in brackish water.
2. Studies on diseases in mariculture were mainly directed on Vibriosis and bacterial diseases. Various methods of immunisation as well as different types of vaccineses were tested. Moreover the tolerance of rainbow trout to nitrogen compounds of brackish water was studied.
3. Promissing results were got from experiments on rearing fry of Hypophthalmichtys molitrix and Anstichthys nobilis x Hypophthalmichthys molitrix in heated brackish water.
4. Aiming at the establishment of an effective cage culture technology under the conditions of the GDR's coast, circular cages were tested successfully. Adequate technological equipment for commercial fish farming is under construction and will be tested next season.

STATISTICAL INFORMATION ON MARICULTURE PRODUCTION - GDR

Species	tonnes
Rainbow trout in enclosures	
- less than 0,5 kg each	354
- more than 0,5 kg each	56
total	410

FEDERAL REPUBLIC OF GERMANY

(K. Tiews)

Crassostrea gigas:

Indoor experiments on the reproduction and rearing of spat were continued as well as outdoor experiments on the fattening of spat to marketable sizes.

Container culture experiments on various places along the German North Sea and Baltic coasts were also continued by the Institut für Küsten- und Binnenfischerei.

Growth rates of spat fed on algae (Nannochloris) diets from phytoplankton cultures are studied under different environmental conditions at the Institut für Meereskunde, Kiel. The aim is to find methods for a routine production of seed oysters.

Rainbow trout:

Techniques for sea cage rearing are developed at the Institut für Meereskunde, Kiel as well as feeding strategies with different diets. The stress which intense cage rearing causes to the surrounding natural environment is investigated. A pilot plant for trout production in silos supplied with brackish water from the cooling system of a power plant is accompanied scientifically. The possibility of sea ranching with 4 to 10 weeks old juveniles early weaned to brackish water of 16°/oo S shall be tested.

The gas-physiology and energetics of trout respiration against several environmental factors is studied under the aspects of optimal growth and production rates.

Cage farming experiments:

Cage farming experiments with rainbow trouts were carried out off the coast of Heiligenhafen, of Langballigau and of Eckernförde by the Institut für Küsten- und Binnenfischerei.

Salmon:

Methods for fry production in Germany and sea water cage rearing techniques are under investigation at the Institut für Meereskunde, Kiel.

Coregonus:

Fry rearing in cages with underwater lights to use the natural zooplankton resource of a lake was continued under quantitative aspects of the Institut für Meereskunde, Kiel. The 6 months old fry is used for a sea ranching project in a brackish water fjord.

Turbot:

Mass production of fingerlings was continued at the Institut für Meereskunde, Kiel. The concept is to rear the larvae with high survival rates on a diet of natural plankton for which cultivation methods are worked out. On the base of plankton algae culture rotifers and copepods, mainly the species Eurytemora affinis are produced. Regarding the latter most biological obstacles have to be overcome.

Eel:

Research on eel farming in heated effluents of a conventional power station was continued at the experimental station Emden of the Institut für Küsten- und Binnenfischerei. Also scaling up experiments for the mass rearing of elvers in silos including the optimisation of feeds for these was continued by the same institute in its laboratories in Hamburg.

Fish nutrition:

Work was continued on the development of fish feeds for rainbow trouts in which fishmeal as protein source was substituted by other conventional and unconventional protein sources (Institut für Küsten- und Binnenfischerei). Also the development of eel feeds was continued by the same institute.

Recirculation sea water systems:

The biological station of Helgoland concentrated work on the optimisation of water quality management in brackish water recycling system, investigations on combined biological-chemical water treatment in intensive fish culture units. Also the Institut für Küsten- und Binnenfischerei continued its work on the development of a recirculating sea water system.

Fish pathology:

Work to develop methods with which to describe stress conditions for fish in intensive aquaculture systems was continued at the Institut für Hydrobiologie und Fischereiwissenschaft of the University of Hamburg.

Physiology:

Cryopreservation experiments on long-terme storage of sexual products of economically important species were continued at the Biologische Anstalt Helgoland.

Statistics (Federal Republic of Germany)

	Tonnes	Approx.No. in 100 000	Value in 1,000 U.S. Dollar
Blue mussels (Mytilus edulis)	10 600	-	1 585
Pacific oyster (Crassostrea gigas) from vertical cultures	8	-	66
Pacific oyster (Crassostrea gigas) seed laboratory reared	-	1	6
Rainbow trout in enclosures and silos less than 0,5 kg each	20	-	48
Eel (Anguilla anguilla) not fresh water	9	-	79

ICELAND

(I. Jóhannesson and S.Tr. Einarsson)

Aquaculture is increasing in Iceland. Production of salmon smolt has increased rapidly during the past two years and the total production is now approximately one million smolts, besides a considerable quantity of fingerlings. Most of the smolt and fingerling production has been released into the rivers and lakes in Iceland.

Increased production of smolts calls for new usage. Therefore experiments with ocean ranching have been taken up round the country. Experiments in ocean ranching have mainly been carried out by the Institute of Fresh Water Fisheries in Kollafjördur, apart from various individual and private enterprise experiments. Very good results have been obtained in Lárós on Snæfellsnes, returns reaching 12-15 percent. Various concerns will now start ocean ranching, including the American organization, Weyerhauser and the Norwegian salmon company, Mowi A/S. These companies have entered into co-operation with Icelandic parties regarding the projects.

The Fisheries Association of Iceland has led the salmon farming experiments in sea water. The experiments of the Fisheries Association in Lake Lón in Kelduhverfi showed that farming in net pens is possible. In continuation the company, Isno Ltd. (founded by Tungulax h.f. and the Norwegian Fish Farming Company, Mowi) have started farming in cages in Lake Lón. In addition to that Mr. Sigurdur Helgason in Grindavík on Reykjanes has taken up salmon farming in tanks on the coast. By pumping warm sea water into the tanks he obtaines good growth of the salmon. The production of the parties mentioned above is still small, but the total production is expected to reach 50 tons this year. In Iceland the total annual salmon catch is approximately 200 tons. The main emphasis has been on the production of salmon smolts, however, char and trout smolts have been produced in small numbers. Farming of other species is very limited.

IRELAND

(Jacqueline Doyle)

Mariculture operations in Ireland have been expanded during the last three years, and both pilot and commercial scale operations are increasing. They are based on both fin fish and mollusc culture.

Fin Fish

Atlantic Salmon (Salmo salar)

Salmon farming is now being carried out at 6 locations on the west and northwest coast using net-pens. Production from 2 units in 1981 was 32 tonnes. This figure is expected to expand in the coming year when the other units are developed.

A pilot scale farm using pumped sea water supplies and intensive aeration is presently under construction.

Major constraints to expansion have been the limited supply of disease free smolts. A bacterial disease, furunculosis, has caused major losses, up to 70% in some instances, following transfer to sea-cages.

Early maturation has also been a problem up to 60% of the stock have been reported as maturing as grilse.

Rainbow trout (Salmo gairdnerii)

Some 9 sea-cage units produced 200 tonnes in 1981. Weights at harvest average 700g-1kg. Attempts to overcome early maturation problems include the introduction of 'all female' ova derived from certified disease-free sources in England and of Norwegian ova from late maturing stock.

The seasonal incidence of algal blooms off the south west coast has posed a major set back to the development of fin-fish farming in that area.

Molluscs

The main species being commercially produced by intensive farming methods are mussels, Mytilus edulis; oysters, Ostrea edulis and Crassostrea gigas; and escallops, Pecten maximus.

Mussels (M. edulis)

Production was 600 tonnes in 1981 from 20 commercial and pilot scale farms. On-growing techniques include rope suspension from rafts, surface long lines and most recently Butchot methods.

Spat utilisation has been successful on a pilot scale and appears to be the most cost effective method to date.

Extensive on-bottom culture of mussels involving the relaying of spat at 2 commercial beds yields 3000 tonnes per annum.

Oysters

Intensive oyster farming has been a relatively recent development in Ireland. There are now some 16 pilot/commercial farms producing 41 tonnes of O. edulis and 13 farms producing 56 tonnes of C. gigas in 1981.

Successful techniques include a pond-breeding system for seed production. Oysters are on-grown off-bottom either by suspending spat in trays on lantern nets from floating rafts or by growing in trays or bays on the shore near low tide mark. A major constraint on the expansion of oyster farming has been the difficulties in getting good quality hatchery reared spat. There is only one commercial hatchery in production and the industry relies heavily on imports.

Escallops

Pilot experiments are in progress with methods of farming escallops (Pecten maximus) and 350,000 spat were re-laid in 8 on-growing sites in 1981.

Settlement intensities and distribution are monitored. Studies on predation and fouling are in progress. On-growing methods are being evaluated.

Research

The following organisations are actively engaged in research work related to mariculture.

(a) Department of Fisheries and Forestry engaged in disease diagnostic work. Currently investigations include the pathology of mortalities associated with algal blooms caused by the dinoflagellate Gyrodinium aureolum. Heavist losses occurred in rainbow trout whereas young salmon in adjacent cages were less severly affected. Significant changes in gill histology indicated that death would appear to be due to tissue hypoxia.

Caged rainbow trout brood stock were heavily infested with sea-lice and Trichodinia infestation of gills was also diagnosed for the first time in salt water. Both conditions responded to treatment and no mortalities occurred. No outbreak of vibrosis or bacterial kidney disease were recorded.

Oysters and mussel culture techniques are monitored and a programme to develope and evaluate scallop culture is in progress. Studies are being undertaken of water quality, possible enrichment of sea-cage sites and the incidence and impact of algal blooms on aquaculture activities.

(b) Beirtreach Teoranta engaged in experimental hatchery rearing of O. edulis and C. gigas and raft culture of both species.

Further sites are being evaluated for nursery and on-growing of both oyster species and also for clams and escallops.

(c) Shellfish Research Laboratory, Carna engaged in development of techniques for low cost outdoor diatom culture and growth and survival trials of O. edulis spat fed from this system were carried out. Experimental work with low cost dinoflagellate production continues. The successful development of a greenhouse oyster hatchery system for both O. edulis and C. gigas is reported.

Hatchery techniques for Mercenaria, Tapes and Venus verrucosa are being developed.

Hatchery production of Abalone is successful and growth and survival trials of spat in experimental sea-cages are satisfactory. Other experiments in progress include the culture of Artemia nauplii and of juvenile lobsters.

(d) University College, Cork
Zoology Department engaged in kidney disease research and fish immunology. Nephrocalcinosis recorded as being more pronounced in rainbow trout in marine systems than in freshwater. Calcium deposition is now regarded as a secondary phenomenon associated with kidney damage and cellular necrosis or accumulation of excess waste or metabolic products in the kidney. Despite intensive sampling Bacterial Kidney Disease has not been diagnosed, but techniques for more sensitive detection are being developed.

(e) University College, Galway
Zoology Department engaged in analysis of the genetic characteristics of salmonids and shellfish of economic importance and developing pilot selective breeding programmes on principle species.

Microbiology Department investigating the pathogenicity of Aeromonas salmonicida, the incidence and control by chemotherapy of latent furunculosis, and the development and evaluation of vaccines for furunculosis.

(f) Salmon Research Trust engaged in research on genetic, disease and nutrition of salmon and trout and in the improvement of smolt rearing systems. Also engaged in salmon ranching experiments.

(g) Electricity Supply Board
Research and development of salmon and eel farming and also salmon ranching.

(h) National Board for Science and Technology
Engaged primarily on the co-ordination, evaluation and development of Mariculture research.

In 1981 this organisation published a major report on "Science and Technology for Aquaculture Development". This report identified the main constraints relating to both technical and development aspects of the industry and suggested broad priorities for future development.

NETHERLANDS

(M. Fonds)

The production of rainbow trout (*Salmo gairdneri*) in cages in seawater is estimated between 50 and 100 tons.

Research on the development of a commercial dry food for culture of Dover sole (*Solea solea*) is carried out at the Netherlands Institute for Sea Research (Texel), in cooperation with the Agricultural University Wageningen and a commercial animal food firm.

NORWAY

(V. Øiestad)

INTRODUCTION

Research on problems related to mariculture is carried out by the following institutions in Norway:

1. Section of Aquaculture, Institute of Marine Research, Directorate of Fisheries, Bergen (including two research stations, Matre and Austevoll)
2. Institute of Vitamin Research, Directorate of Fisheries, Bergen
3. The State Biological Station, Flødevigen, Arendal
4. Research Station for Salmonids, Sunndalsøra and Averøy, Agricultural University of Norway
5. Institute of Fisheries Biology, University of Bergen
6. Institute of Fisheries, University of Tromsø
7. Regional High School, Sogndal
8. National Veterinary Institute, Oslo.

In the following report these institutions are referred to by number. (1) and (4) have continued their long term experiments on salmonids in 1981. The other institutions are mainly concerned with short-term experiments both on salmonids and on new potential species for aquaculture.

RESEARCH PROJECTS

Genetics

Experiments with selective breeding of Atlantic salmon and rainbow trout were continued at (1) and (4). The following sub-projects are included,

a. Selection program to increase growth rate, (1) and (4), reduce mortality (4) and improve meat quality (4) increase age at maturity (4).
   At Sunndalsøra and Averøy about 300 full sib families of Atlantic salmon and rainbow trout are tested in each year-class.
b. Study of phenotypic and genetic parameters in production taits, (1) and (4).
c. Study on inbreeding depression, (4)
d. Study of heterosis effect, (4)
e. Induce polyploid to obtain a tripolid steril fish, (4)
f. Induce gynogenesis, (4)
g. Selection is applied for brown trout to improve (4) tolerance to acidic water, growth rate and recapture frequency.

Behaviour

A project concerning antipredator behaviour in Atlantic salmon smolts was started (1). The behaviour of cultivated smolts in relation to potential fish predators (cod, saithe, trout and pollack)was observed in a tank in order to find out possible differences in smolt reactions to predators. Later on will be tried conditioning of smolts to avoid predators in an effort to improve recapture of released smolts.

Physiology and nutrition

Laboratory experiments of nutrition, digestion, growth, metabolism and energy budget of cod have continued (1). The studies on the effect of smolt size on subsequent growth rate and age at sexual maturation, were finished. The experiments with feeding of salmonid fry with steroids to obtain sterile or unisexual fish were continued in a small scale.

Use of Calanus for pigmentation of salmonids was further tried out (1), and so was use of shrimp wastes for salmonid feeding.

Acidified feeds treated with hydrochloric, formic or sulphuric acid were fed to rainbow trout to test the effects on protease activities, growth and feed utilization (2). Silage conservation of fish feed including long term effect, health and meat quality was studied by (4) including shrimp wastes, was also studied by (1). Studies on protein, fat and carbohydrate level in fish food, digestability, feed consumption at different temperatures and of varying fish sizes, and comparisons of wet and dry diets in salt water at low temperatures were carried out by (4).

Experiments on lipoid liver degradation (1) and studies on egg quality of reared farmed salmonids have been continued (1) and (4).

Use of binders in salmonid feeds (to increase feed efficiency and reduce water pollution) was studied by (2). About 30 different available products were tested for consistency and degree of decomposition in water. Of these, ten was further studied with regard to digestability and effect on growth rate of trout.

Pathology

The work on vaccination and vaccines against vibriosis has been continued (1) in cooperation with the Institute of Fisheries, University of Tromsø. The prosject will be finished early in 1982 and hopefully a vaccine production on commercial scale will then be developed. Different disease problems at local fish farms have been looked into and special attention has been given to the cold-water vibriosis or Hitra-disease. Work on pathological conditions in wild populations has also continued and a national registry on such conditions has been started in cooperation with the Institute of Medical Biology at the University of Tromsø. The work on spreading of IPN virus from known carriers in fish farms to the marine environment was continued as planned (Ph. D. thesis).

Retention time of different antibiotics at varying temperatures is studied (4 and 8), data is collected to study different environmental sources causing the Hitra syndrome (8), death rate in Atlantic salmon due to Costia necatrix in full sea water has been observed and different treatment has been applied (8).

Aquaculture technology

Experiments to assess the effectiveness of several antifouling impregnants for net pens and rearing tanks were continued in an reduced scale in 1981 (1).

Storage of live saithe in net pens for subsequent delivering to the fishing industry was studied (1) also in 1981. Especially the effet of handling and thowing were paid attention to also this year.

Studies of resirculation of fresh water for smolt production were carried out at (1) and (4). Oxygen consumption and effect of varying oxygene levels as well as effect of supersaturation with nitrogen were studied at (4).

Raising of smolt in net pens in freshwater and use of submerged cages for fish farming in the sea were studied by (1). Treatment of acid water for smolt production was also paid attention to (1).

Rearing of marine fish larvae

Experiments on hatching and rearing marine fish larvae and fry in land situated basins (3), plastic bags in the sea (1) and a closed poll (1) and (5) were continued. In plastic bags and the poll cod larvae were reared. Natural food was used in these experiments.

Other projects

Experiments on commercial culture of mussels, Mytilus edulis, were continued, (1) and (7), and similar experiments on growing oysters and scallops were initiated (1), (6) and (7). Concerning oysters especially, possible positive effect on growth rate of raising oysters in the vicinity of fish farms was paid attention to.

At (6) the investigations of the possibility for culture of anadromous Artic charr, Salvelinus alpinus, both in freshwater and in sea cages, were continued. These investigations include hatching and first food uptake, osmoregulation and the effect of environmental factors as light and stocking density on growth rate.

STATISTICS

Quantities of salmonids produced are given in the enclosed questionaire. The main mariculture production in Norway still is rainbow trout and Atlantic salmon. The public statistics give no breakdown on production in fresh and salt water, and the production in fresh water is not reported in the inland fisheries statistics. Thus the total production is given in the questionaire. However, the quantities produced in fresh water is small, and 2-3% of the total production is indicated. Concerning other species, no statistics exist, but small quantities of blue mussels and oysters were produced.

OUTLINE FOR STATISTICAL INFORMATION ON MARICULTURE PRODUCTION +)

Mariculture production 1981

Country ..... Norway .....

Species	in metric tons	approx. number in 100 000	value in 1 000 US $
Blue mussel (Mytilus edulis) from culture beds	.....	-	
" " from vertical cultures	.....	-	
Flat oyster (Ostrea edulis) from culture beds	.....	-	
" " from vertical cultures	.....	-	
" " seed	-	.....	
Portuguese oyster (Crassostrea angulata) from culture beds	.....	-	
" " from vertical cultures	.....	-	
" " seed	-	.....	
Pacific oyster (Crassostrea gigas) from culture beds	.....	-	
" " from vertical cultures	.....	-	
" " seed	-	.....	
American oyster (Crassostrea virginica) from culture beds	.....		
" " from vertical cultures	.....	-	
" " seed	-	.....	
Common scallop (Pecten maximus) from culture beds	.....	-	
" " from vertical cultures	.....	-	
" " seed	-	.....	
Queen scallop (Chlamys varians) from culture beds	.....	-	
" " from vertical cultures	.....	-	
" " seed	-	.....	
Lobster	.....	-	
" seed	-	.....	
Shrimps	.....	-	
Other crustacean (specify)	.....	-	
Rainbow trout in enclosures less than 0.5 kg each	.....	-	
" " more than 0.5 kg each	4500-5000 tons	-	46 000
Salmon in enclosures	8400 tons	-	14 000
Other salmonids (specify)	.....	-	
Eel (Anguilla anguilla) (not fresh water)	.....	-	
Sole	.....	-	
Turbot	.....	-	
Sea bass (Dicentrarchus)	.....	-	
Others (please specify)	.....	-	

+) Clear working definitions should be provided for terms used i.e. seed vertical culture, seed laboratory reared etc.

POLAND

(No report received)

PORTUGAL

(J.D. Ataide)

Lobster Culture - Experiments on artificial incubation of Nornay Lobster (Nephrops norvegicus), and rearing of the larvae and post--larvae, were carried on all over the year. The majority of the post-larvae attained 6 to 10 mm of carapace length in a period of about 6 months. The experiments are to be continued with the juveniles in order to obtain age/length relationships

Shrimp culture - Experiments on hatching and rearing of larvae and post-larvae of Palaemon serratus, from the south coast of Portugal, were carried out. The main purpose of these experiments were the collection of a large number of zoëas of the same age, in order to avoid canibalism problems, and the improvement of the recirculation systems used in previous years. The larvae and post-larvae were reared in different culture systems. The use of a sandy bottom in a closed system with a low level of agitation, proved to be unsuitable because the Artemia sank immediatly after furnished and remained on the surface of the sand being unavailable to the larvae. This fact was never noticed when no artificial substrates s were used. Experiments of the same kind are now being continued, with stronger agitation.

The post-larvae were reared at different densities in different kinds of artificial substrates.

Experiments were carried out on the induction of the maturation of the gonads of Penaeus kerathurus, from July to December, under controled conditions: high constant temperature levels and different photoperiods. Copulation and maturation of the ovaries were often obtained in all cases but spawning was never performed.

Amphipod culture - Experiments are being performed in the culture of the Amphipod Gammarus locusta, using a wild brood stotck for reproduction and rearing the juveniles at different levels of temperature, food and light periods, in recirculation systems. The aim of these experiments is to provide the larvae and post larvae of fishes and crustaceans with a source of natural food as an alternative to Artemia and others.

MARICULTURE

Production 1981

Extensive Fishfarming

Area -	500 ha	
Mean production -	500 kg/ha/year	
Species -	Mullet - (Mugil)	45%
	Eel - (Anguilla)	15%
	Sea Bass - (Disentrarchus)	
	Sole - (Solea)	15%
	Gilt-head bream - (Sparus)	
	Others	25%
Annual production	250 metric tonnes	

Bivalve molluscs - mainly carpet shell (Venerupis)

Area -	400 ha - Effectively exploited area-150 ha
Mean production -	30 metric tonnes/ha/year
Annual production -	4 500 metric tonnes

SPAIN

(No report received)

SWEDEN

(Bo Holmberg)

Rainbow trout:

Since 1978 the Swedish production of rainbow trout has doubled each year and in 1981 a total production of 2000 tons aimed for the commercial market was achieved. Further, rainbow trout was stocking in lakes for recreational purposes. About 40% of the 2000 tons of rainbow trout was raised in brackish and marine waters in net pens. Only one operation with throughflow water was in use in 1981. The main part of the production consisted of 0.4-0.9 kg size rainbow trout.

Atlantic salmon and sea trout:

Salmon and trout smolts were raised up to smolt stage for stocking in the Baltic area. Due to the decisions made by the Swedish Water Right Court 2 millions of salmon smolts have to be stocked every year in the Baltic to compensate the natural reproduction which is no longer possible in some rivers.

Additional salmon and sea trout smolts have been stocked successfully in coastal waters to enhance the stocks aimed for commercial as well as sportfisheries.

Successful experiments have been performed to cultivate salmon in net pens in the Baltic area. Special attention has been paid to overcome overwintering problems.

Blue mussel:

Methods for cultivating mussels on vertical strips instead of ropes have been evolved. About 500 tons were harvested in 1981. Prospects for much higher harvests the following years are good. The ecological effects of such cultivation on the bottom sediment and the surrounding water have been studied. Except for the local impact the negative effects are negligible so far.

UNITED KINGDOM

(A.L.S. Munro)

All commercial mariculture activities are located on the west coast of the Scottish mainland and in the islands.

Fin Fish Atlantic salmon (Salmo salar)

Salmon farming continues as both the biggest and fastest growing mariculture industry. Production in 1981 increased to 1133 tonnes compared to 598 tonnes in 1980 and of the total 81.5% was salmon, the rest grilse. Smolts placed in seawater in 1981 numbered 1.539 million, a 10% increase on the previous year. It is estimated that approximately 50% of 1979 smolts did not survive to be harvested and that for each smolt placed in sea water 1.26kg of salmon were produced for consumption. Most losses are believed to occur in the first 6 months of sea life from a variety of causes including inability to tolerate sea water salinity, infections disease, escape, predation and accidents. An estimate of production for 1982 based on smolts placed in sea water in 1980 and 81 is a minimum of 1700 tonnes, more if survival of smolts in sea water has improved as some industry sources claim.

In 1981 some 24 companies were recorded operating 32 sea cage sites and 4 pumped sea water land based tank sites compared to 21 sea cage sites and 3 pumped sea water systems in 1980.

Rainbow trout (Salmo gairdnerii)

A total of 7 sea or brackish water cage sites produced 112 tonnes of trout in 1981 compared to 86 tonnes in 1980. The size of fish harvested ranged from portion size to 3-4kg.

Others

Eel (Anguilla anguilla) production exceeded 100 tonnes from one farm using

cooling water from a power station. Small tonnages of Dover sole (Solea solea), turbot (Scophthalmus maximus) and sea bass (Dicentrarchus labrax) were also produced in heated sea water. Commercial fattening trials using juvenile turbot in unheated sea water in sea cages are in progress. The turbot were reared in heated sea water initially.

Molluscs

Some small increases in commercial production were recorded in 1981. The position remains much as reported for 1980.

Research

Seven groups are actively involved in aspects of mariculture research, funded from public sources, namely:

Dunstaffnage Marine Research Laboratory, Oban, Argyll. Investigation of the causes of death of farmed fish from plankton kills, definition of hydrographical and other physical factors important at sea sites, and research on the use of industrial fish species and fishery wastes for farmed fish feedstuffs.

Heriot Watt University, Edinburgh. Recirculation systems and cage engineering.

Institute of Aquaculture, Stirling University. Several aspects of tilapia culture including nutrition, genetics, maturation and disease control. Additionally nutritional requirements of salmonids, environmental effects of salmonid cage culture and disease control and diagnosis.

Institute of Marine Biochemistry, Aberdeen. Aspects of the nutrition of salmonids and marine flatfish.

Marine Laboratory, Aberdeen. Research on disease control and diagnosis in salmonids, investigation of methods of control of sexual maturation and sex and smolting processes in salmonids.

Torry Research Station, Aberdeen. The definition of standards of quality for farmed salmonids.

Sea Fisheries Authority, Hunterston and Ardtoe. Development of methods of culture of sole, turbot and scallops.

U.S.A.

(J.H.Ryther and A.C.Longwell)

The following report is divided into two parts. The first concerns the U.S. Sea Grant research program on aquaculture as conducted in U.S. universities. This is taken from sections of the Annual Sea Grant Report, 1981, Section on Aquaculture, as prepared by Dr. Kent Price.

The second portion of the report concerns the mariculture research conducted on the East Coast by the National Marine Fisheries Service, Northeast Fisheries Center, NOAA, U.S. Department of Commerce. This work is carried on at the Milford (Connecticut) Laboratory and concerns shellfish.

Next year an effort will be made to cover federal government activities on the West Coast, industry research and academic research not covered by the U.S. Sea Grant Program.

The government research described in the second half of this report is in more detail than the Sea Grant research. More detail on aspects of the latter is available through the Office of Sea Grant, NOAA, U.S. Department of Commerce, and the U.S. Mariculture Committee members to ICES.

U.S. SEA GRANT PROGRAM

Marine Shrimp

Research in this area is directed toward control of shrimp maturation and reproduction, nutrition, culture requirements, genetic marking, and control of microbial diseases of marine shrimp (University of California and Texas A&M University). In addition efforts are being made to understand the toxic effects of certain marine blue-green algae of penaeid shrimp (University of Arizona) and to determine the economics of commercial shrimp mariculture (Texas A&M University and University of California). Researchers are also examining the possibility of artificial insemination and hybridization of shrimps (South Carolina Consortium).

Freshwater Prawn

The efforts involving Macrobrachium are directed toward the development of feeds, avoidance of toxicants and demonstration of commercial prawn farming methods (University of Hawaii and South Carolina Consortium).

Crawfish

Louisiana State University is continuing efforts to improve crawfish production and the South Carolina Consortium is developing techniques for artificial insemination and hybridization of crawfish.

Blue Crab

A single project involves the identification of nutritional requirements during larval development of blue crabs using microencapsulation techniques (University of Maryland).

Brine Shrimp

Research here is directed toward regulation of the production of dormant cysts by the brine shrimp (University of California), defining the nutritional value and toxicity of selected strains of brine shrimp for culturing finfish and other animals (University of Rhode Island), and determining the feasibility of a brine shrimp fishery on Abert Lake, Oregon (Oregon State University).

Finfish

Salmon

The salmon projects involved address 1) regulation of disease, particularly furunculosis and bacterial kidney disease (University of Idaho and University of Washington) and infectious pancreatic necrosis (University of Maine/New Hampshire), 2) endocrine control of smoltification and its relation to growth rate (University of Minnesota, University of California, University of Washington and Woods Hole Oceanographic Institution), 3) imprinting through odorant recognition (Oregon State University), 4) the use of quick freezing in gamete preservation (University of Minnesota), 5) reproductive physiology and induced maturation of salmon broodstock (Oregon State University and University of Washington), 6)survival and nutritional requirements of salmonids in transition from freshwater to a marine environment (Oregon State University), 7) developing diets and optimizing chum and coho culture techniques (University of Washington and Oregon State University), 8) genetic evaluation of aquacultured salmon and interaction with wild stocks (University of Alaska), and 9) economic analysis of the salmon production practices and the interrelationship between wild and hatchery salmon (Oregon State University).

Other Finfish Projects

General projects involve 1) basic husbandry of Great Lakes fishes (University of Wisconsin), 2) nutritional requirements and the effect of environmental stresses on growth, quality, and production of cold water cultured fishes (Oregon State Uni-

versity and University of Wisconsin), 3) fish feed development (University of Alaska and Virginia Graduate Consortium) and 4) demonstration of finfish mariculture in South Carolina (South Carolina Consortium) and in North Carolina (University of North Carolina).

More specific projects involve: 5) control of sexual differentiation in yellow perch (University of Wisconsin), 6) nutrition and parasites of the cultured American eel (University of North Carolina and Clemson University), 7) culture of the walleye (State University of New York and Iowa State University), 8) evaluation of striped bass-white perch hybrids for use in aquaculture (University of North Carolina), 9) bait minnow culture and the influence of zooplankton productivity in fish hatchery ponds (Ohio State University), 10) the development of microencapsulated foods for larval fishes (Massachusetts Institute of Technology), 11) OTEC cold water fish culture (University of Hawaii), and 12) the nutritional and economical consequences of the Maillard Browning reaction in fish feeds (University of Rhode Island).

Mollusks

Oyster

A major effort involving growing oysters in a self contained greenhouse system, is a multidisciplinary approach to developing and demonstrating controlled environment mariculture at the University of Delaware. Other efforts are directed toward 1) understanding the basis of disease resistance in these animals (Virginia Graduate Consortium) and the role of larval American oysters as carriers of oyster diseases (State University of New York), 2) encouraging oyster growers to adopt recent advances in oyster growing tecnology including the use of eyed larvae as an oyster seed source (Oregon State University), 3) demonstration of hatchery technology and the value of genetics in molluscan culture studies and understanding the contribution of algal abiosis to oyster larval deaths (University of Washington), 4) understanding nutritional requirements, development of artificial food for oyster larvae and utilization of brewery wastes for oyster mariculture (University of Delaware and Virginia

Graduate Consortium) 5) development of chemical techniques for controlling oyster drills (University of Delaware and University of Washington), 6) examining growth and survival in wild oyster populations (University of Maryland), and 7) assessing the ability of bivalves to directly absorb amino acids from the environment (University of California).

Clams

Projects in this area of research are directed toward 1) an evaluation of seed clam planting in Long Island (State University of New York), South Carolina (South Carolina Consortium), and Oregon (Oregon State University), 2) understanding survivorship,bioenergetics, genetics and breeding structure of hard clam populations and demonstrating clam culture (George Mason University and Virginia Graduate Consortium).

Abalone

Abalone research efforts are directed toward the use of biochemical engineering and understanding the physiology of fertilization in hybrid formation, experimental seeding efforts, and an economic analysis of the abalone fishery, to improve commercial abalone production (University of California). An experimental abalone enhancement program in the natural environment is being conducted by the University of California.

Scallop

Efforts are underway to artificially control spawning and larval production in the purple-hinge rock scallop for aquaculture purposes (University of California) and to develop a seeding program for bay scallops in Massachusetts (Woods Hole Oceanographic Institution).

Bivalves in General

With the use of larval culture techniques and scanning electron micrographs a larval key is being developed (New Jersey Marine Science Consortium). Development of lipid specific staining

techniques for assaying condition in cultured bivalve larvae is progressing nicely (Woods Hole Oceanographic Institution).

Other Aquaculture

Animals

Efforts are being made to develop bait markets and a production industry for the bait leech (University of Minnesota) and the Maine baitworm (University of Maine/New Hampshire). Texas A&M University is examining imprinting in marine turtles. The University of Hawaii is developing techniques for the propagation of rare coral. Other efforts involve selective breeding of bullfrogs for prepared diet acceptance and disease control (Louisiana State University) and culture of sulfur bacteria as food for filter-feeding shellfish (Woods Hole Oceanographic Institution). The University of Delaware developed the Second International Conference on Aquaculture Nutrition with emphasis on the invertebrates.

Plants

A number of efforts are directed toward the cultivation of seaweeds (University of California, University of Hawaii, and University of Washington). Specificially studies address 1) seaweed crustacean polyculture (State University System of Florida), 2) potential of two species of Gracilaria for mariculture in the Mariana Islands (University of Guam) and Euchemia farming in Ponape (University of Hawaii), 3) use of artificial substates, improved seed stock and net seeding (University of Washington) and OTEC platforms (University of Hawaii) in the culture of seaweeds, and 4) the application of radioisotope techniques to seaweed production (University of Maine/New Hampshire).

Two rather unique studies involve 1) the use of seawater in irrigation of typical commercial agricultural crops such as barley and tomatoes (University of California) and 2) the development of new food and forage crops from naturally salt tolerant marsh plant species (University of Delaware). The New York Sea Grant Institute is developing techniques for producing marine biomass

from seaweeds while Mississippi State University is testing the use of marine algae in the production of alcohol in waste water recovery.

Pathology

Several studies (Listed in Commercial Fisheries) are directed toward understanding the distribution and pathogenicity of vibrios and related species in shellfish (Louisiana State University, University of Maryland and Oregon State University). Other studies address 1) the toxic effects of certain blue-green algae on penaeid shrimp (University of Arizona), 2) the development of health certification criteria for transfer of molluscan stocks (New York Sea Grant Institute) and 3) contribution of genetic end environmental factors to the virulence of marine vibrios (University of Washington).

Education, Advisory and General

Aquavet, a unique training program for aquatic veterinarians is being conducted at Cornell University (State University of New York) and the University of Washington is developing a diagnostic pathology training program. Oregon State University is offering a course in management - oriented aquaculture training. The University of Delaware prepared a digest of aquaculture research that was published in October 1981.

Although there generally is an element of aquaculture in almost every Sea Grant marine advisory service program (described in another section of the annual report), the University of Hawaii has a special advisory effort relating to the development of the freshwater prawn industry while the University of Washington and Oregon State University offer special advisory services to the shellfish industry.

An effective effort on the development of a national Sea Grant aquaculture strategy has been supported through various programs througout the Sea Grant network. The strategy will be presented to appropriate representatives of the mariculture community for

review in the near future and is described in more detail in a later section of this report.

Trends

Currently of the $ 3 735 000 federal Sea Grant dollars being spent, approximately $ 2 717 000 (or 73% of the FY 1981 Aquaculture Budget) was spent on the high priority species (hard clams, American oysters, freshwater prawns, salmon, and marine shrimp) or generic problems having wide application, identified in the National Aquaculture Plan and the National Sea Grant Aquaculture Strategy.

However, no research is now underway involving mussels and it would appear that a greater emphasis could be placed on nutrition, genetics, disease, drug certification procedures, and water quality control in order to better match national priorities.

Accomplishments

In March of 1981, a Sea Grant Task Force of Sea Grant Directors identified nearly 22 million dollars of annual economic benefits that were related to previous Sea Grant research involving crayfish farming, pen-reared salmon, oyster culture (both natural and controlled environment), ocean ranching, disease control in salmon and shellfish culture, freshwater prawn culture, and assistance to the newly developing shellfish culture industry in Maine.

MILFORD LABORATORY, NORTHEAST FISHERIES CENTER, NOAA, U.S. DEPARTMENT OF COMMERCE

Spawning and Rearing of Molluscs

A major effort to determine the feasibility of bay scallop (Argopecten irradians irradians) culture in a three-dimensional lantern net system in Long Island Sound was made in 1981. The nearly 40,000 bay scallops with a minimum shell height of 20 mm required for this test were produced in-house using hatchery and raceway technology developed here. In these experiments scallop growth, mortality and adductor muscle yield at densities between 100 and 2500 scallops/m^2 were investigated. Additionally, various net-handling strategies were explored. Final samples were taken in November and December and the results are still under analysis; however, interim observations indicate that single-season growth to market size is obtainable in this type of intensive culture system. Future experiments will investigate the effects of depth and other physical, chemical and biological influences on this type of system.

Additional information on bay scallop survival during the winter has been obtained, but it remains a topic worthy of further work. There was relatively high (75%) survival of hatchery-raised bay scallops held in estuarine environments during the 1980-1981 winter, contrasted with low survival during the previous winter. It appears that survival of hatchery-produced stocks may depend on planting before the ambient water temperature drops below 10°C to allow for acclimation in the new environment before very cold temperatures occur.

Some positive results have been obtained in experiments to determine how early in the year small bay scallop seed can be put into Long Island Sound without sacrificing viability. Hatchery-reared scallops, 8 mm in length, placed in suspended pearl nets in April at an ambient water temperature of 5°C were all alive and had grown to 20 mm by June when the water temperature reached 15°C. Previously it was thought that growth rate and survival of bay scallop seed at these temperatures would be low. These results mean that hatchery seed produced in early spring

can be immediately planted out, greatly reducing hatchery holding capacity and heating and feeding costs.

The use of small-mesh pearl nets suspended in Long Island Sound was explored as a method to grow hatchery-raised bay scallops to a size suitable for final grow-out in lantern nets. In addition, the effectiveness of the pearl nets was compared with our raceway system. In 10 weeks scallops 10 mm in height initially grew to a mean height of 30 mm at densities as high as 2500/m^2. At densities higher than this an inverse relationship between density and final height was observed. The very acceptable growth of small bay scallops in pearl nets at moderate to high densities may make this a cost-effective alternative to raceway culture.

Considerable new information has been attained on optimal algal concentrations for the efficient growth of bay scallop larvae. The optimal concentration is about 10,000 cells/ml, 5 to 10 times lower than the concentration routinely used to grow shellfish larvae. Concurrent tests to determine larval grazing rates indicated a consumption rate of about 100 cells/larva/hour for medium-sized larvae. If these values hold in a more critical evaluation planned for early 1982, a continuous feeding strategy, maintaining about 10,000 cells/ml in larval cultures, would require only 35% of the algae now used in the culture process without reducing growth rate.

Experimentation was performed to determine the thermal and nutritional conditions needed to induce gametogenesis in the surf clam, Spisula solidissima, out of synchrony with nature. Histological data assessed developmental changes in gonad under the experimental conditions, while physiological data indicated metabolic changes. Optimal conditions were defined as a result of this project.

Work continued in evaluating the effectiveness of submerged cages in protecting surf clam seed from predators in the natural environment, while permitting

growth to a marketable size. Boxes filled with a sand or gravel substrate raised off the bottom produced the best results.

The hard clam, Mercenaria mercenaria, and the soft shell clam, Mya arenaria, were reared in the pumped raceway system to evaluate their growth performance in this situation. The growth rates of both species compared favorably with growth rates reported in nature and in aquacultural systems. The growth rates compared to the surf clam and scallop were much lower, precluding a one-year marketable product from the raceway.

Basic physiological data were obtained for the surf clam. Filtration rates and food assimilation efficiencies were measured under different conditions. This background information will be used in evaluating the physiological well-being of animals in specific systems.

Breeding and Genetics of Oysters

Results of the first selected generation of American oysters (Crassostrea virginica) in the two-way selection experiment for fast and slow growth were analyzed and prepared for publication. In 5 of 7 companion groups the fast-growth lines were, statistically, significantly larger than their contemporaneous slow-growth lines when the spat were measured at roughly 2 years of age. There was no evidence that selection of oysters at 2 years had an effect on larval growth rate. A second selected generation was bred in the spring of 1981 and is now being measured. A third selected generation will be bred this spring of 1982. This is intended as a pilot demonstration experiment which will provide, each oyster generation, new information about the extent to which artificial selection can improve growth rate of these oysters under prevailing hatchery conditions.

Three generations of full-sib crosses of the same oyster reveal some inbreeding depression in some lines. The depression observed is not discouraging in terms of the practicality of obtaining highly inbred oysters for either more basic research

or for test-crossing in an evaluation of inbreeding-crossbreeding programs for commercial production. Of 43 second-generation full-sib and 22 outbred control crosses made over 3 years (1979-1981), 3 times more outbred crosses metamorphosed than did inbred ones.

Rather broad examinations of the crossability and performance of C. virginica from a wide range of geographic locations have been conducted. Long Island Sound oysters have been crossed successfully with oysters from Texas, Florida, Virginia, Maryland, Fisher's Island, Rhode Island, Massachusetts, New Hampshire, and Maine. Interspecies hybridization of Long Island Sound oysters has been attempted with C. rhizophorae, C. gigas, C. angulata, and C. corteziensis. With one exception, species crosses were not successful. There may be some positive heterosis in particular intra-species crosses, and this should be substantiated as interest or need arises. Some examination of biochemical genetic differences in the several geographic groups was undertaken.

Control of Molluscan Disease

Diseases of larval molluscs

Bacterial identification and disease control service work were emphasized during 1981. Five hatcheries assisted include: Monterey Abalone Farms, Monterey, CA (consultation visit - 3 isolates identified); International Shellfish Enterprises, Moss Landing, CA (consultation visit - 3 isolates identified, 1 pathogen found and eliminated); Cozy Harbor Sea Farms, West Southport, ME (water quality information); Jenkin Pacific Shellfish Co., Berkeley, CA (toxin information); and Marine Bioservices, South Bristol, ME (71 isolates identified, 3 pathogens found and eliminated). Additional service work included an on-site experiment which showed ozonized ice to preserve fresh salmon in Homer, AK; a monthly coliform test completed on local hard clams for the Connecticut State Aquaculture Division; and cooperative research with Fairfield University to develop a chemical test for

paralytic shellfish poison identification in shellfish meats (136 mouse assays). Service work will continue with renewed emphasis on disease prevention, using seminars and scientific presentations to teach sanitation to commercial, federal, and state personnel.

Throughout 2 years (1979-1981) of studying the natural oyster beds at New Haven, Stratford, Bridgeport and Norwalk, Connecticut, the Stratford site has shown the greatest number of pathogens. In 1981 this field survey was completed and the data reported to the 1981 National Shellfisheries Association meeting in Williamsburg, VA. A new study was initiated to identify why Stratford has such a high pathogen prevalence. Since, historically, the Stratford shellfish bed has been a poor producer of oysters, it is considered important to determine whether a relationship exists between the bacterial flora (230 new isolates taken) and the low oyster numbers.

A contract with Dr. Willard Hartman, Yale University, showed that chlorine-produced oxidants are more damaging to oyster larvae when discharged from a point source than from the three prior sites in New Haven Harbor. Another contract with Dr. John Buck, University of Connecticut Marine Laboratory, Noank, indicated that Candida albicans, a pathogenic yeast, is taken up as food by clams and oysters and does not depurate with the controlled addition of UV-treated water.

Both contracts relate sewage discharge to shellfish habitat degradation and shellfish product contamination in the environment.

Mechanisms of bacterial pathogenicity

The main research emphasis this year was on an exotoxin produced by a Vibrio species previously isolated from naturally occurring epizootics among oyster larvae, Crassostrea virginica, reared at Milford Laboratory. Bioassays demonstrated that the LC_{50} value was less than 46.6 µg of toxin per 1-liter culture of oyster embryos (15,000). This quantity of toxin was produced by 2.9×10^9 colony-forming units.

Purified toxin showed neither proteolytic nor amylase activity; it did, however, demonstrate bacteriostatic capability. The toxin is heat-labile. Bioassays showed that exposure to heat-destroyed toxin was beneficial to oyster embryonic development; this phenomenon will be investigated further. Studies showed that 7 out of 8 other pathogenic bacterial strains also produced metabolites toxic to oyster larvae; 6 produced exotoxins, while the other produced an endotoxin.

A year-long bacteriological study comparing two types of media was conducted. Data indicate that seawater agar plates, routinely used in this laboratory for bacteriological samplings, yield a greater variety of colonies than do estuarine agar plates, described by Weiner, Hassong, and Colwell, 1980 (Can. J. Microbiol. 26: 1366-1369). For the second year in a row, a pathogenic red pseudomonad that frequently plagues hatchery-reared larval cultures has been isolated from flowing seawater. This suggests that the red pseudomonad colony-forming units are present in very low numbers, too low to grow out on the agar plates. Another study conducted this past year showed that oyster embryonic development was greatly enhanced if 10 μm filtered seawater used in culturing was charcoal-filtered before being exposed to ultraviolet light radiation.

Immunity in aquacultured organisms

Biochemical and immunodiagnostic tests to identify disease-causing bacteria rapidly are important elements of a program to control disease during hatchery production, seed production and growth of molluscs. A modified basal medium was developed for use with the Minitek biochemical differential system in identifying marine bacteria. This basal medium improved the correlation between many of 31 standard biochemical reactions and the more rapid Minitek reactions on 65 marine bacteria. However, some Minitek reactions were inhibited - possibly by the seawater incorporated into the medium. Additional work is planned on some of these tests to provide further improvements in the test system. False negative reactions in the oxidase test, an important biochemical reaction in the identification of pathogenic marine vibrios, were found to be eliminated when bacteria

were initially grown on Mueller-Hinton agar modified by addition of NaCl and Hepes buffer.

Serum antibodies were developed in striped bass, then isolated, purified, and injected into rabbits for the production of rabbit anti-striped bass serum. This latter reagent will be used in enzyme-linked antibody tests for pathogenic bacteria after employing striped bass to produce antibodies to a variety of pathogens.

Identification of viral diseases is hampered by the lack of molluscan cell lines for the growth of viruses. In cooperative work with Western Connecticut State College, cell surface transformation was induced in trypsin-dissociated larval oyster cells with selective dose ranges of dimethylnitrosamine. Hopefully, this work will lead to a method for initiating cell division in cultures of oyster tissue and, eventually, to a stable cell line.

Identification and analysis of markers for disease resistance are useful measures in improving the control of disease in molluscan growth systems. This requires *in vitro* work with phagocytic hemocytes. A spectrofluorometric technique was adapted for measurement of malic dehydrogenase (MDH) in oyster hemocytes. The malic enzyme triggers a reaction which produces a highly fluorescent compound which can be measured with a spectrofluorometer. The method is about 30 times more sensitive than a more commonly used spectrophotometer method for measuring MDH. The technique will be used to measure cell damage and subsequent cytoplasmic leakage during various *in vitro* experiments.

Because *in vitro* work with molluscan immune cells has required many tedious hours of cell counting at the microscope, a simple, more accurate method of enumeration was developed. Fluorescamine, a reagent which fluoresces when it combines with amino groups in proteins and peptides, was used to measure protein in molluscan cells which had been lysed with Triton X-100. This method is sensitive

enough to measure total protein of 300 to 1000 cells. Most of the variables, such as optimal pH, effects of protein protective reagents and stability of reagents, were worked out for publication of the technique. Additional work on comparison with protein standards and evaluation of variability in cell-protein content between animals is planned.

Aspects of Nutritional Requirements of Molluscs

The work conducted in this investigation falls into four major categories: (1) laboratory experimentation under highly controlled conditions, (2) maintenance of a collection of unicellular estuarine algae, (3) culture in large volumes of algal species known to be good molluscan food sources as a service to Milford Laboratory investigations, (4) consultation with academic and commercial personnel on problems relative to algal culture and molluscan feeding. Each of these categories contributes toward fulfilling the mission of the Aquaculture Division, i.e., to discover basic and applied information that will increase productivity of the molluscan fisheries through aquaculture.

(1) Laboratory experiments - An investigation was conducted to determine the tolerance of four species of algae to high concentrations of copper, cadmium, and zinc in growth media. Since molluscan hatcheries are located in coastal areas where pollution with metals from domestic and industrial wastes is prevalent, it is important to understand how a high concentration of metals in the water supply can affect growth of algae cultured for molluscan food. In addition, information on the effect of metal-contaminated algae on grazing oyster larvae was desired.

Tolerance to metals in artificial seawater was much greater than in enriched natural seawater, presumably because of the higher concentration of metal ligands in the former medium. Growth of M. lutheri and I. galbana was inhibited considerably more than that of the other test organisms by Cu and Cd although this difference did not occur in media with excess Zn. Algae developed tolerances to

metal concentrations that were growth inhibitory upon initial exposure. Strains of I. galbana adapted to grow in a medium with 10 mg% $CuCl_2$ (47.3 ppm Cu) or 2.5 mg% $CdCl_2$ (15.3 ppm Cd) fed to laboratory-reared veliger larvae of the oyster, Crassostrea virginica, induced poor growth and high mortalities in grazing larvae.

There are several directions in which future research may be aimed. Investigation into the concentration of metals accumulated by the algae of both adapted and non-adapted strains would be of considerable interest. Future research might examine the effect of a metal-contaminated food source on growth of juvenile oysters; also an examination of the possibility of multiple adaptations - is the strain adapted to copper simultaneously adapted to tolerate cadmium or other metals?

A significant study was completed on food preferences in juvenile oysters. An original rearing chamber was designed and constructed to minimize variations in the rearing environment and to reduce maintenance time. A continuous flow of filtered, temperature-controlled, ultraviolet-treated seawater washes the molluscs that are suspended on a screen of appropriate size.

Crassostrea virginica spat were reared in this chamber on different algal diets. The chambers functioned effectively, oysters increased in weight and there were no mortalities in those fed useful diets during 13 weeks of observation. Growth of oysters was similar and rapid when fed Tetraselmis maculata and Thalassiosira pseudonana, less rapid when fed Dunaliella euchlora, and decreased still further with Phaeodactylum tricornutum as a food source. Unfed oysters and those fed Chlorella autotrophica both showed no change.

Future research will be directed toward investigation of the nutritional value of algae for which no information is available.

Other feeding studies were conducted with C. virginica juveniles in basin culture, using freeze-dried algae as food. Oysters failed to grow on this diet.

The particles fed were rejected in an abundant production of pseudofeces. Additional work should be conducted to learn why this dried food is rejected. The elucidation of this phenomenon probably holds important clues to understanding the nature of the feeding process in C. virginica.

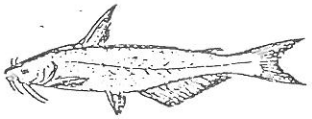
(2) Stock culture collection - The investigation maintains a collection of 97 strains of estuarine unicellular algae. All strains, with three exceptions, have been purified and are now in axenic culture, each in three types of medium. Subcultures of all strains are conducted according to a schedule, which ranges from 2 to 8 weeks. Strains in the collection are used in our experimental procedures, used as starter cultures for the mass culture effort, and made available to qualified outside investigators.

Special strains are also maintained by periodic subculture in sterilized growth media, e.g., strains adapted to tolerate high metal concentrations and a freshwater strain that is being adapted to tolerate seawater. Cultures of food organisms in flasks of large-volume capacity are also maintained to provide starter cultures for the semi-continuous culture system.

(3) Semi-continuous mass culture system - This system, designed to produce sufficient biomass to supply molluscs studied at the Milford Laboratory with a source of nutrition, consists of 30 sterilized 5-gallon Pyrex carboys. Each culture is harvested weekly and the displaced volume is replaced by pre-sterilized medium. The species cultured at present are axenic strains of the following: Monochrysis lutheri, Isochrysis galbana, Dunaliella euchlora, Tetraselmis maculata, and Thalassiosira pseudonana. Every effort is made to keep these cultures free of bacterial contamination. The average harvest per month is about 3,500 ml of high density. The investigations that receive the harvested algae are: Physiological Effects of Pollutant Stress, Spawning and Rearing of Molluscs, Pathobiology, and Aquacultural Genetics.

AQUACULTURE

Aquaculture may be defined as the culture or husbandry of aquatic animals or plants by private industry for commercial purposes or by public agencies for augmenting natural stocks. With the passage of the National Aquaculture Act of 1980, Public Law 96-362, in September 1980, it is incumbent upon the Secretaries of Agriculture, Commerce and Interior, where appropriate, to undertake a continuing assessment of the United States aquaculture industry. The following table presents for the first time U.S. commercial aquaculture production of marine, brackish, and freshwater species. Information on freshwater species was obtained from the Department of Agriculture based on their 1980 catfish and trout survey.



U.S. AQUACULTURE PRODUCTION, BY SPECIES, 1979 AND 1980 (1)

Species	1979		1980	
	Thousands pounds	Thousands dollars	Thousand pounds	Thousand dollars
Fish:				
Catfish	40,600	28,800	76,700	53,600
Salmon	2,400	900	7,600	3,400
Trout	25,000	21,000	48,000	37,500
Shellfish:				
Oysters	6,800	11,600	7,200	12,300
Clams	8,900	5,400	9,100	5,600
Shrimp (prawns)	-	-	300	1,200
Total (2)	83,700	47,700	148,900	113,600

(1) Data shown are live weight harvest for consumption except for oysters and clams which are meat weight. Data for oysters and clams are included in commercial landings. Excluded are eggs, fingerlings, etc. which are an intermediate product level.
(2) These estimates do not include aquaculture production for all species such as abalone, mussels, striped bass, crawfish et al., which is estimated to be about 12.0 million pounds.

Note:--Data shown in this table contain estimates. Some species may not be shown to avoid disclosure of private enterprise.

As excerpted from "Fisheries of the United States, 1980 (April 1981), Current Fishery Statistics No. 8100, U.S. Dept. Commerce, NOAA, National Marine Fisheries Service.

U.S.S.R.

(A.A.Elizarov)

Basic results of the research works carried out in the USSR in 1981 in the following fields:

- artificial cultivation of sea and diadromous fishes;
- commercial cultivation of fish in sea water;
- cultivation of invertebrates;
- cultivation of algae.

Investigation of the factors determining population dynamics and stock structure of White seaherring has been continued in the White sea, and also methods of increasing its reproduction efficiency have been improved. There was made a survey of the spawning grounds, which may be suitable for installation and further testing of traps-spawning grounds. For the purpose of studying population structure of the stock out of different bays we collected the data on herrings in which different quality of spawner eggs have been ascertained. Herring infestation with certain helminths (before that only monogenetics were used as parasite-indicators) testifies again not only of the existence of local groups, but evidently of differences in the extent and the areas of fattening migrations of certain herring populations.

In the Black sea and partially in the Azov sea we have ascertained the most promissing objects of mariculture for this region: mullet (grey mullet, golden grey mullet) and dabs (turbot and flounder).

For the elaboration of biotechnology of artificial cultivation and rearing of these species the following research works have been carried out:

- catching and transportation of spawners for the purpose of taking mature eggs and milt out of them after keep-

ing them in water reservoirs (turbot, flounder) and hypophysis injections (grey mullet, golden grey mullet);

- mastering of method for artificial fertilisation of mullet eggs, which permits to obtain high rate of fertilisation (up to 95%).

Optimum density of fish eggs distribution in incubation, and also the shape of incubation facilities have been determined.

There has been established the area of optimum temperature and salinity of water for the development of mullet (grey mullet) embryos and larva and also for the most efficient utilisation of organism inner resourses for its growth and development.

It has been found out that the optimum salinity for fertilisation, incubation of fish eggs and raising of larva during the first ten days of their life is 17-18 pro mille.

The analysis of bioenergetics of larva, resorption speed of yolk sac as well as of larva development speed at different temperatures (from 18 to 27^{0}C) indicates that the optimum development of the larva obtained from spawners of the first rush for spawning is possible at 20-22^{0}C, and that the larva obtained from the spawners of the second rush for spawning - at 22-24^{0}C.

The energy exchange analysis on the basis of the results of respirometric experiments and weight growth of mullet larva and fry with regard to the fluctuation of their calorie value in the course of growth has been carried out: then diagrams of daily food requirements upon feeding with rotifer and artemia nauplius have been calculated and compiled.

Threshold and critical concentrations of oxygen in water have been established for one-year-old and yearlings of mullet reared at different water temperatures.

We are carrying out long-term selection and genetic works aimed at the creation of hybridogenic breed of sturgeons for mariculture. Various forms of Bester (Huso huso L. and Acipenser ruthemus L.) were used as the initial material. The amount of fish eggs obtained from bester spawners F_I reached up to 5-6 mln pieces.

In 1981 we made significant progress in obtaining next generation (the third) of bester,- this is of special importance. Eggs of two bester females F_2 were used, upon fertilisation of them with soft roe of males F_2 ,- high rate of fertilisation has been received (84,3 & 88,4%), and survival rate of the larva which started active feeding reached 40 and 78%. Average weight of bester yearlings F_3 reared in the ponds is 80-85 g. (40-140g). Both females gave rise to monotypic progeny, which was superior in quality to F_2 and closer to F_i . According to the frequency of chromosome aberrations F_3 embryos did not differ statistically from F_i and parental species; and this permits to assume the manifestation of selection effect and theincrease of genetic stability (genic balance) in F_3.

We have started the works on selection of steelhead salmon with the aim to create a breed adapted to the conditions of rearing in sea traps on the Black sea.

A sea trap of light-duty type for fish cultivation in bays and embayments has passed the industrial tests. This trap is characterised by high operation properties and storm resistance. Due to certain improvements made in the design of this trap the specific rate of expense on the production volume of the trap has been decreased by 1,5.

The utilisation of tanks for cultivation of water-fleas and chironomidae on the films gave an opportunity to carry out specific arrangement of food basis for the juvenile sturgeons in test ponds of Krasnodar Sturgeon Plant.

The cultivated food substance comprised the basis for juvenile sevryugas (90-95% of the food bolus weight), and consequently the weight of sevryuga juveniles has increased by 160% and the survival rate - by 25% as compared to the control items, where Copepoda prevailed in the zooplankton.

We have completed testing of the formulas for protection of trap netting from encrusting and fouling organisms. The application of such formulas permits to decrease the intensity of encrustation by 90-95%. And at the same time the rate of biological accumulation of metals in the body of cultivated fish and environment contamination were practically nil.

In the Black sea the first experiments were carried out on commercial cultivation of steelhead salmon in sea water ponds. After 60 days of growth salmon yearlings with initial weight of 55 g reached commercial weight of 125g.

In the Azov sea the experiments with the striped bass brought from the USA for acclimatisation purposes have indicated that the striped bass can be used in aquaculture successfully.

There has been formed a brood stock and progeny received of local spawners stock. We have mastered and improved the method of artificial cultivation of this species. The fertilisation rate is 80-90%, larva yield from one 5-6 years old female: 200-250 thousand pieces. Fish eggs waste at incubation is 10-15%. The same spawners may be used repeatedly during several years.

Out of the local stock of spawners we obtained only 220 thousand larvas and 22 thousand one-year-olds. The grown up and viable juveniles, about 20 thousand pieces were transfered to various fish farms for the arrangement of a new brood stock. 2 thousand pieces wrere released into Taganrog game bay for acclimatisation.

For the purpose of formation of a new brood stock we have brought this year from the USA 4 thousand striped base juveniles with average weight of 300 mg.3,5 thousand one-year-olds were reared out of them with average weight about 60 g.

In 1981 the investigations were continued for the improvement of methods of planting material growing-up and also for commercial growing of silver salmon andtrout in the coastal waters of the White sea.It has been found that the Far East silver salmon makes a promissing object for commercial cultivation in the Polar coastal area.

M U S S E L S

Experimental works on cultivation of mussels in the Barentz sea during 3 years were completed in 1981.

In the course of experiments we determined the intensity of pelagic mussels larvas settlement onto an artificial basement.The bulk of soft tissue in the cultivated mussels fluctuated a lot during the whole year and depended on the size and biological conditions of the organism.The biochemical composition of mussel body is also subject to significant seasonal fluctuations.

The scientific research works which have been carried out since 1976 permitted to compile a temporary manual on biotechnics of mussels cultivation on warp systems in the Barentz sea.

In the White sea we have carried out a comparative parasitological investigation,which has indicated that the mussels reared in suspended aquaculture were practically free of parasites,whereas the mussels of this type,but taken out of natural settlements were infected in some cases at the rate of 80-100%.

We have continued the investigations of the peculiarities of mussels development and growth at different substrates of raft-collectors.

We have studied the relations of mussels and starfishes for predators fighting and improving biotechnics of mussels cultivation.We have worked out methods f or joint cultivation of mussels and laminaria.Certain information has been collected on the ecology of some encrusting organisms of artificial substrates.

S E A M I C R O P H Y T E S

The study of commercial sea weeds reserves (laminaria, rockweeds,Ahnfeltia) in the White and Barentz seas is being carried out.The reserves are estimated by aqualung divers with the use of aerofotosurvey.The biology of laminarias and red alga (Rhodymenia,Furcellaria,Polyhydes) is being studied,particularly: their life cycle,peculiarities of growth and reproduction.

Much attention is being paid to the possibilities of laminaria sacchariferous cultivation in the White sea and along Murmansk coastal line of the Barentz sea.We have been studying the peculiarities of laminaria sacchariferous development on artificial substrates,growth and disintegration of various layer parts of the plants of different age and during different seasons.

The investigations in the White sea during 1981 were aimed at the improvement of laminaria cultivation methods. We studied the peculiarities of development of gametophyte and early sporophyte in laminaria saccharifer ous.Also we studied the influence of bacteria-alga film on the settlement of laminaria zoospores under the conditions of mussels-laminaria bioculture.

We have continued the experiments on improvement of biotechnics of live food cultivation at the experimental mullet plant in Odessa.Sea microalgae (sea chlorella) were cultiveted in 10 l.flasks under artificial light and in two cultivators of closed type (screw type and circulation type) in sun light.The culture medium was:medium Tamia with urea

for nitrogen source and agricultural fertiliser media.

The productivity of sea chlorella depending on illumination rate amounted to 5-20 g from I sq.meter of the illuminated area per 24 hours.There has been elaborated a design of pipe-like unit for the production of sea chlorella with the capacity of 500 g of dry sea weeds per 24 hrs.

Cultivation of rotifers was made in 100 l.and 1000 l. tanks located in the open air and under roof.Bread yeast and sea chlorella were used for feeding.Maximum densities (about 300 pieces/ml) were obtained in case of cultivation in the open air.Upon initial sowing 200 pcs/ml the speed of population growth was 2,3 times higher than upon initial sowing 50 pcs/ml.

We have mastered a method of decapsuling artemia eggs with the use of our reagents (sodium and calcium hypochlorite).